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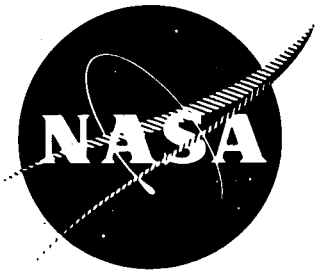



# COMPOSITE HUB/METAL BLADE COMPRESSOR ROTOR

by Sam Yao



FIBER SCIENCE, INC.
Gardena, California 90248

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA Lewis Research Center
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16. Abstract

The objective of this program was to design and fabricate a low cost compressor rotor for a small jet engine. The rotor hub and blade keepers were compression molded with grahite epoxy. Each pair of metallic blades was held in the hub by a keeper. All keepers were locked in the hub with circumferential windings. Feasibility of fabrication was demonstrated in this program.

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# FOREWORD

This report represents the work accomplished by Fiber Science, Inc. during the period December 1974 to October 1975 on NASA Contract NAS3-18926, "Composite Hub/Metal Blade Compressor Rotor." The work was administered by the National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio with Dr. T. T. Serafini, Project Manager.

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# 1.0 SUMMARY

A composite-hub/sheet metal blade compressor rotor, first stage, was designed in accordance with NASA-furnished envelope dimensions. The rotor is made up of a hub, blades, blade keepers and circumferential windings. The hub is designed with twelve (12) cavities to accept 12 pairs of sheet metal blades and their keepers. The circumferential windings hold the keepers and blades to the hub. Recesses are provided on the hub and keepers to house the windings so that a smooth contour with the hub is maintained. Figure 1 shows the completed rotor.

The hub, blade keepers and the circumferential windings are all Thornel 300/epoxy and the blades are steel.

A total of two hub assemblies were fabricated and shipped to NASA for testing.

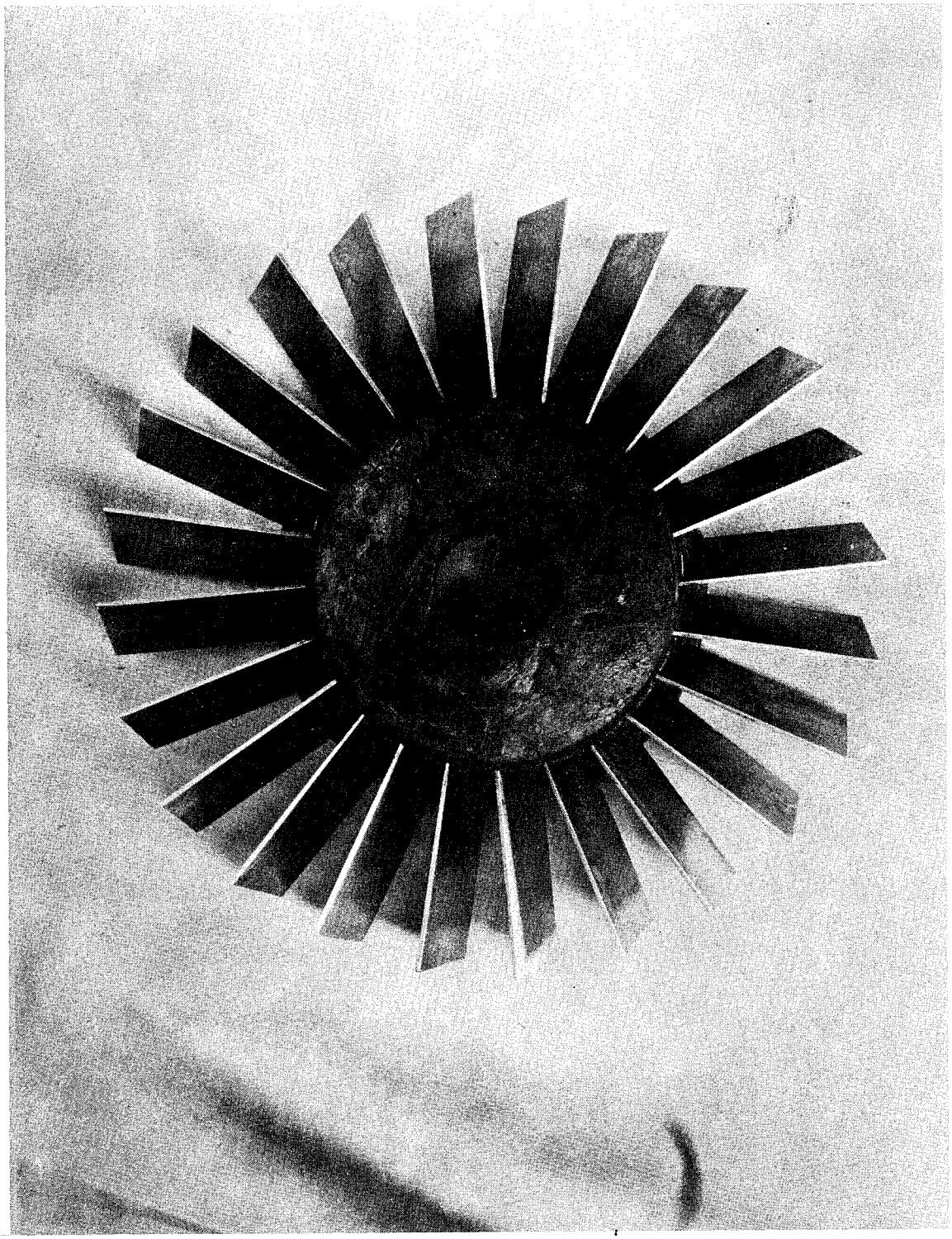

Figure 1. Composite-Hub Sheet Metal Blade Compressor Rotor

## 2.0 INTRODUCTION

One of the major deterrents to small jet engines is the high cost of the compressor rotor. Fiber Science, Inc. conceived a design concept which combines sheet metal blades with a compression molded composite hub that offers low cost potential. The objective of this program was to demonstrate this design concept with the fabrication of two rotors.

This report contains a description, drawings and photographs of the composite hub/metal blade compressor rotor and the tooling used in its fabrication.

## 3.0 CONFIGURATION

The configuration of the composite-hub/sheet metal blade compressor rotor is shown on the following drawings:

| Drawing | |
|---|---|
| 609-001 | Compressor Rotor Assembly Composite Hub/Metal Blade |
| 609-002 | Hub |
| 609-003 | Keeper Blade |
| CD659688 | Sheet Metal Blade Pair (Flat) |

The hub, blade keepers and the circumferential windings are all made of Thornel 300 graphite (product of Union Carbide Corporation) and APCO 2447/APCO 2345 resin (product of Applied Plastics Company). The fiber volume ratio is 50 percent.

The blades are sheet metal and were NASA-furnished for this program.

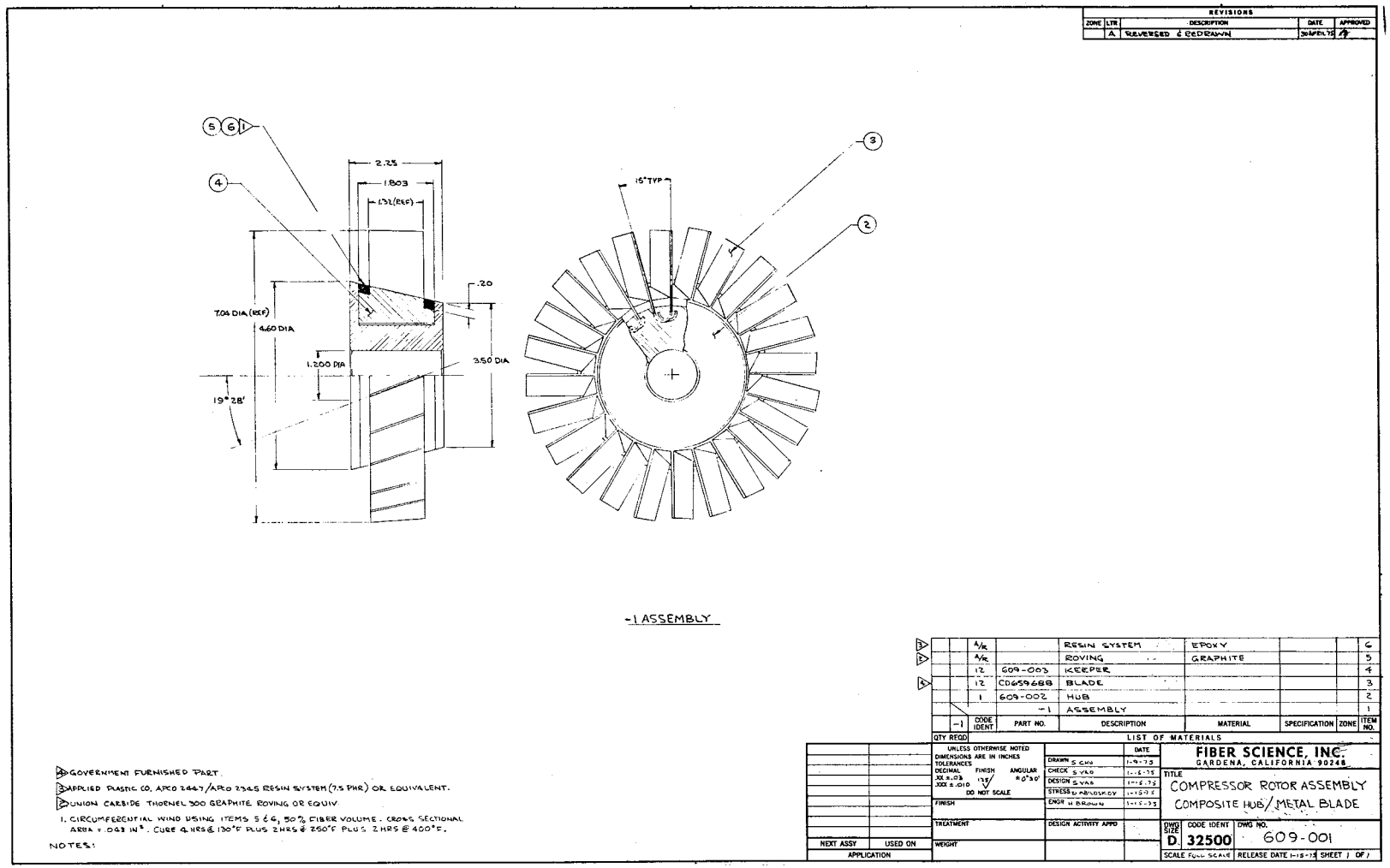


Figure 10. Compressor Rotor Assembly Composite Hub/Metal Blade, Drawing No. 609-001

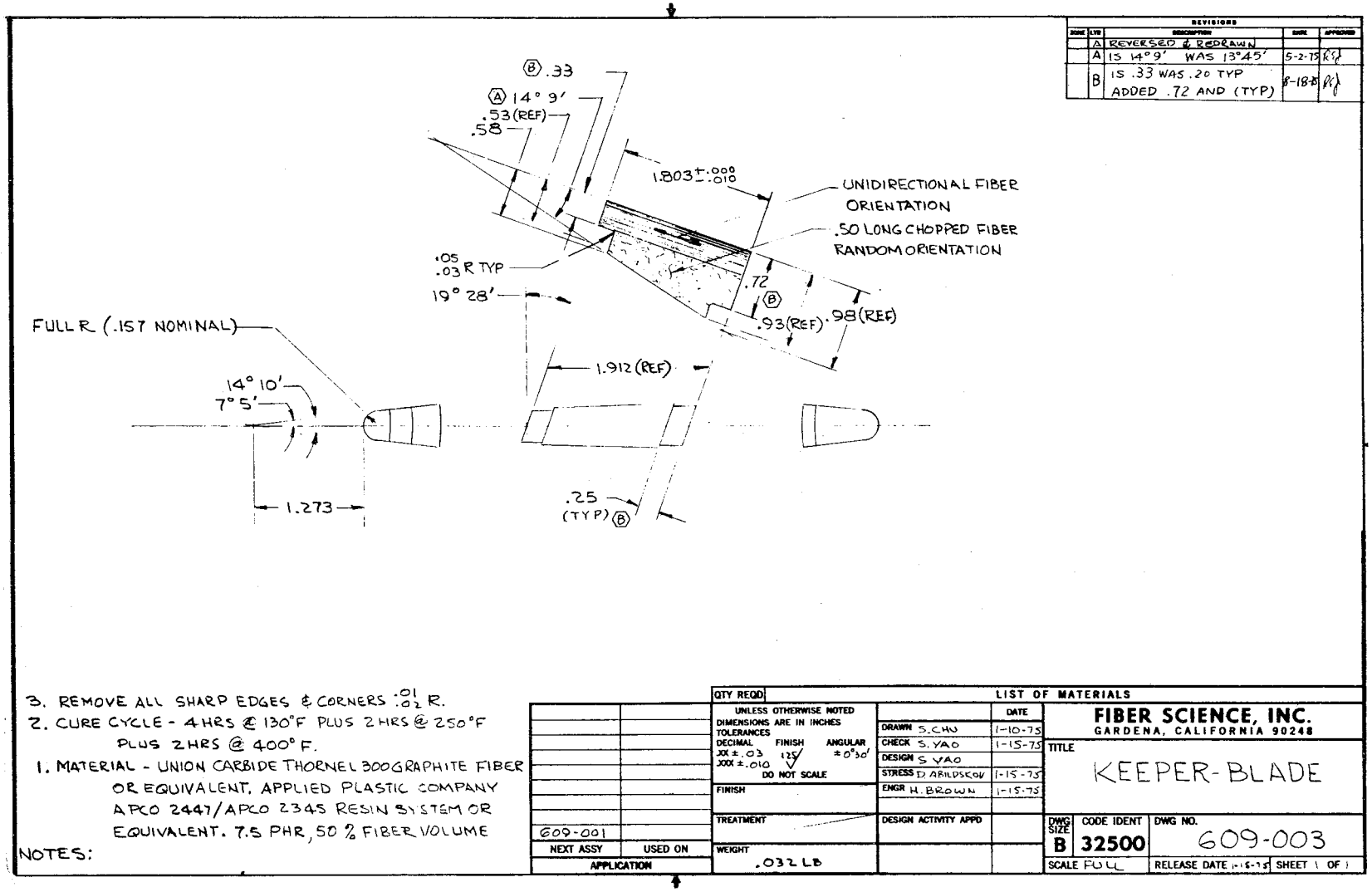


Figure 11. Keeper Blade, Drawing No. 609-003

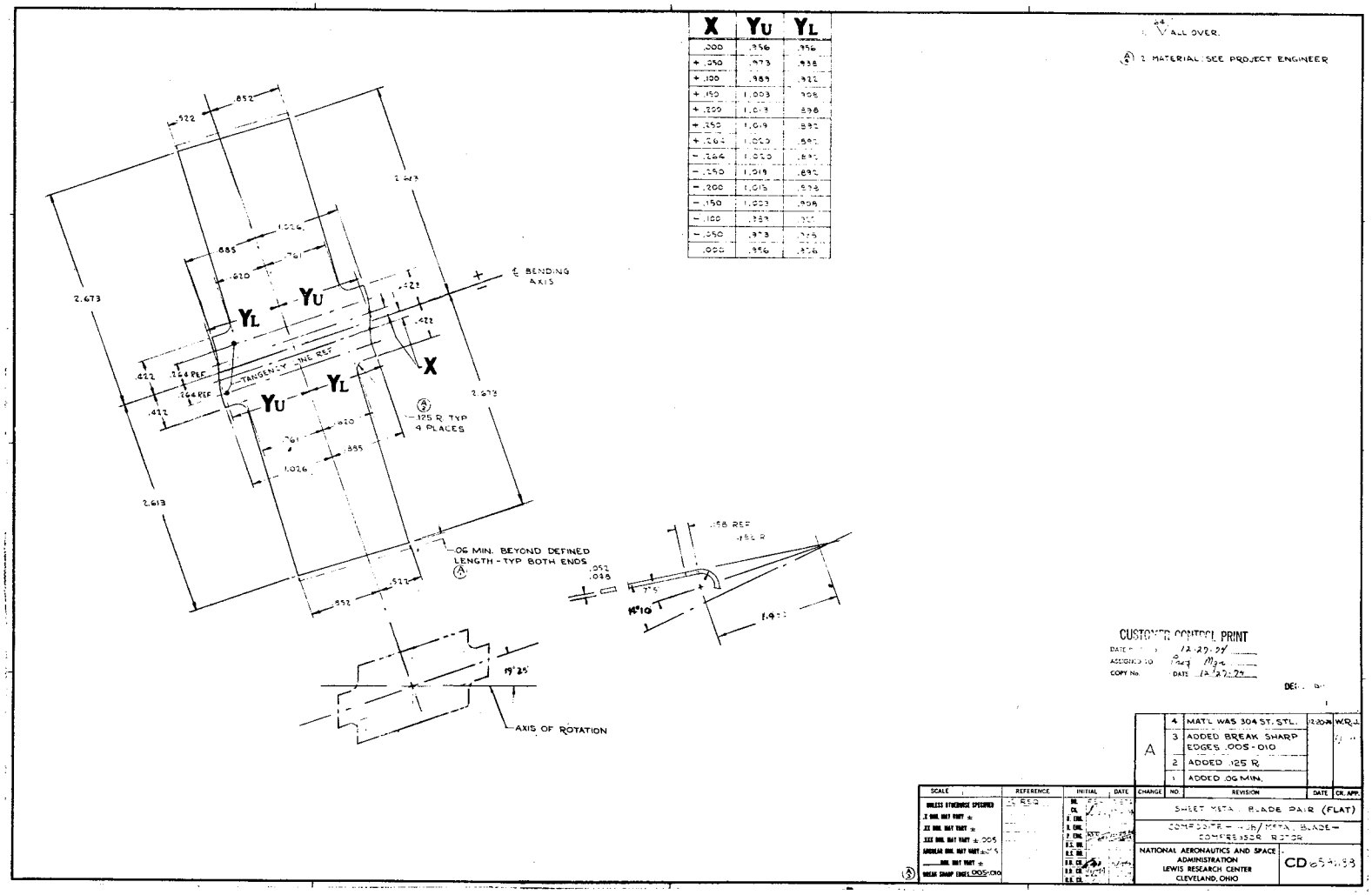


Figure 12. Composite-Hub/Metal Blade-Compressor Rotor, Drawing No. 659688

# 4.0 TOOLING

The tooling to fabricate the hub, blade keepers and assemble the blades and keepers (circumferential winding) are shown in the following drawings.

| Drawing | |
|---|---|
| 609-101 | Mold-Fan Blade Hub |
| 609-102 | Mold Keeper |
| 609-103 | Keeper Fixture |
| 609-104 | Loading Tool Mold-Fan Blade Hub |

Photographs of the tooling are shown in Figures 7 through 9.

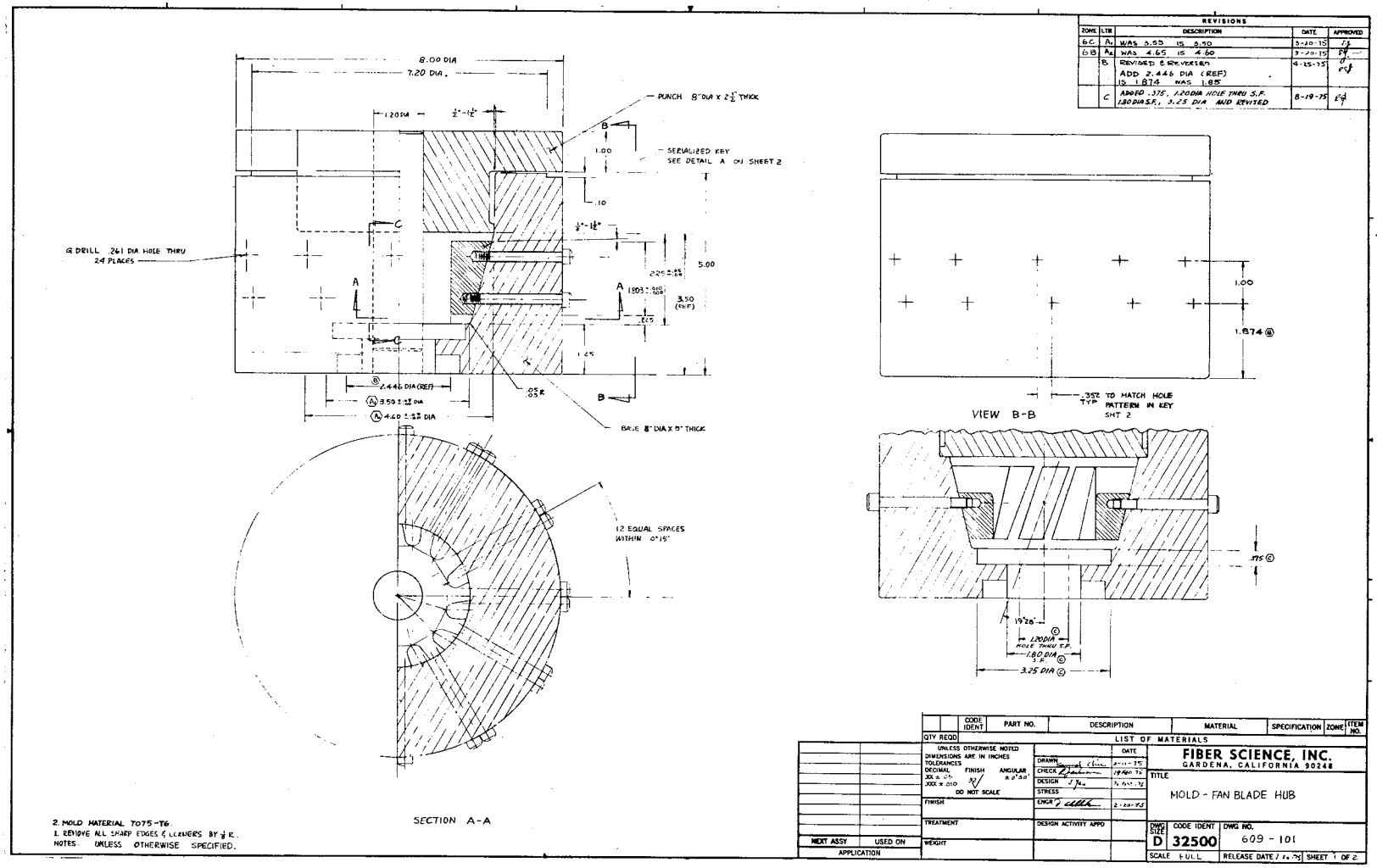


Figure 2. Mold-Fan Blade Hub,Drawing No. 609-101

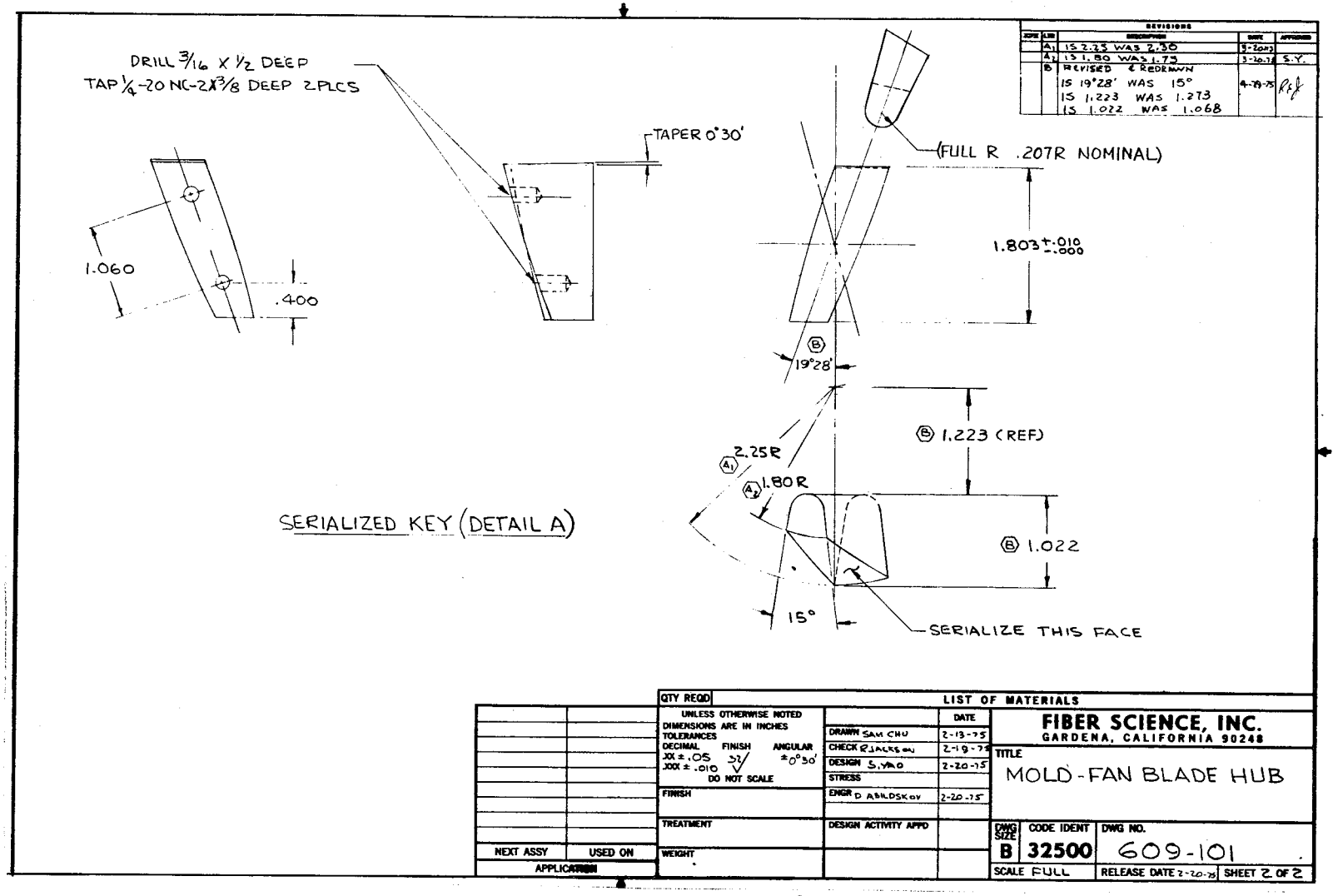


Figure 3. Mold-Fan Blade Hub, Drawing No. 609-101

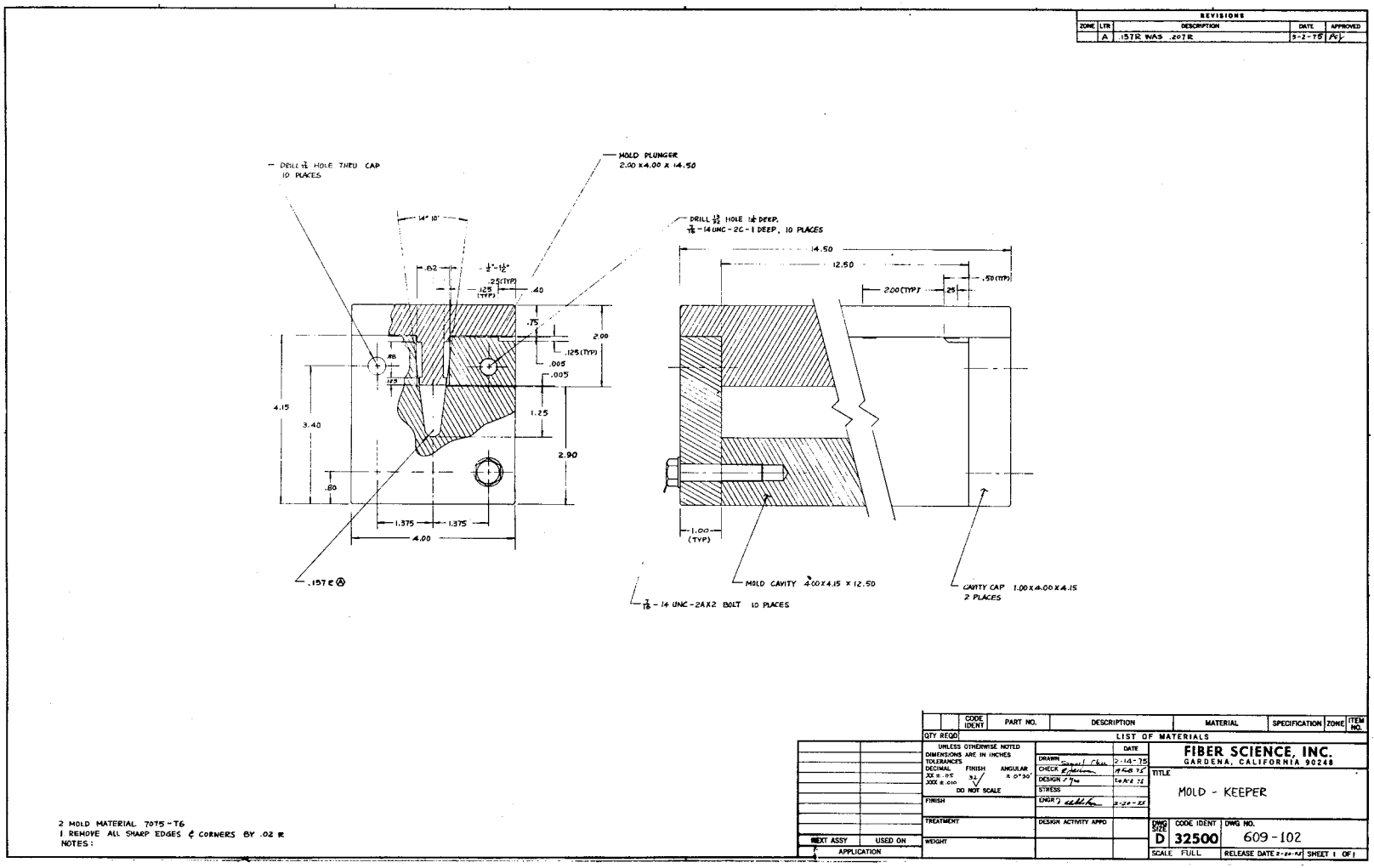


Figure 4. Mold-Keeper, Drawing No. 609-102

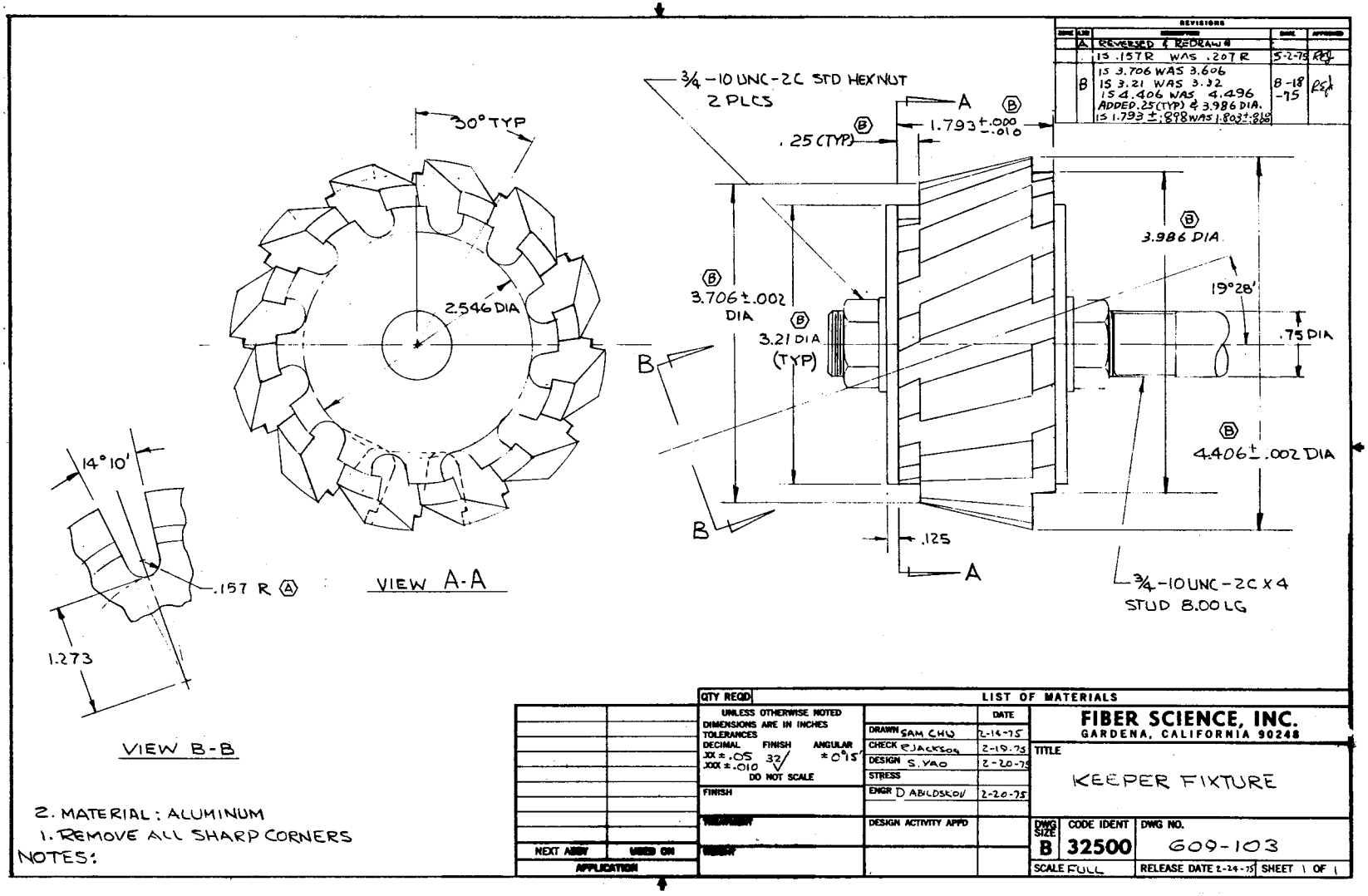


Figure 5. Keeper Fixture, Drawing No. 609-103

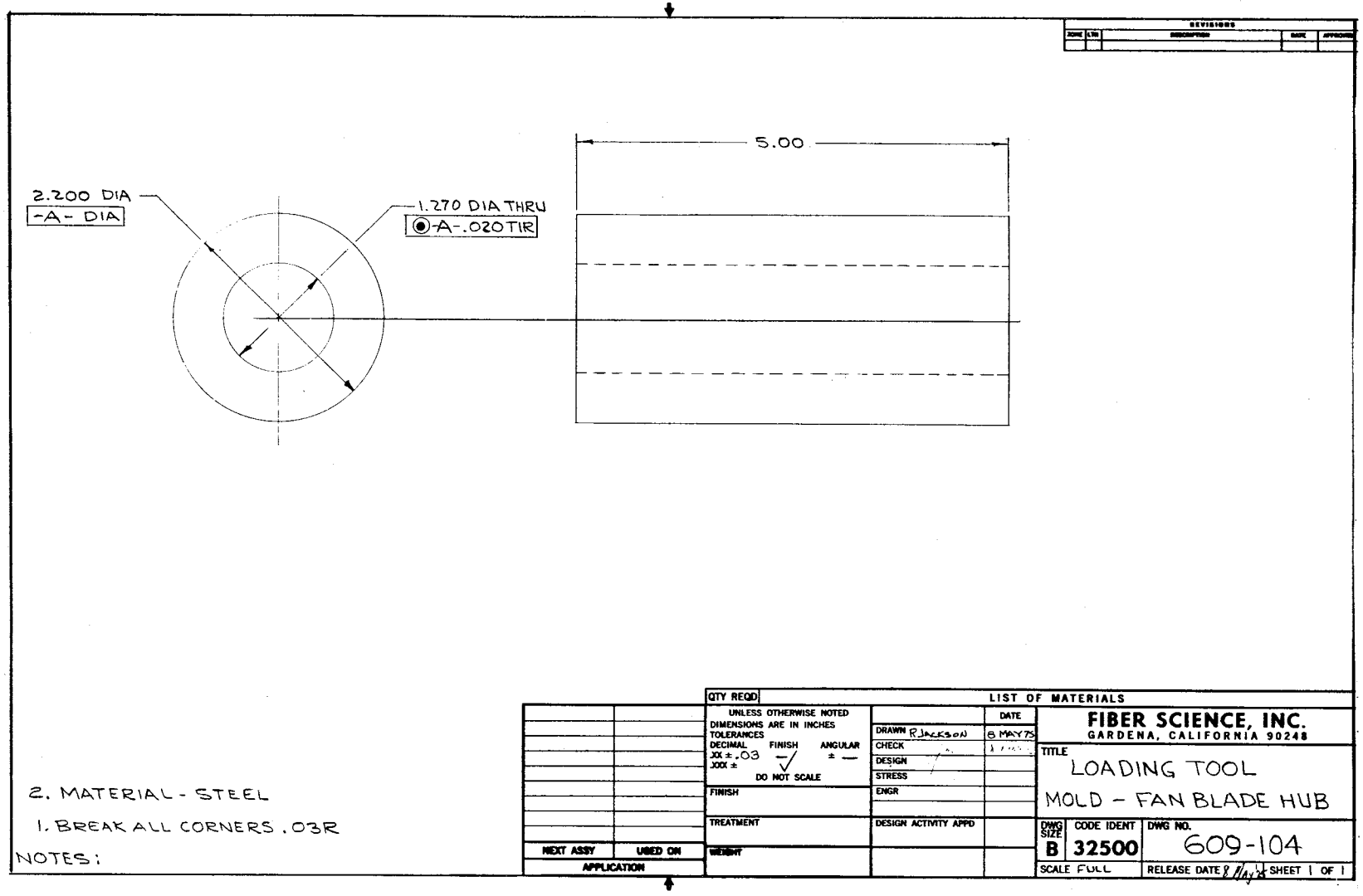


Figure 6. Loading Tool Mold-Fan Blade Hub, Drawing No. 609-104

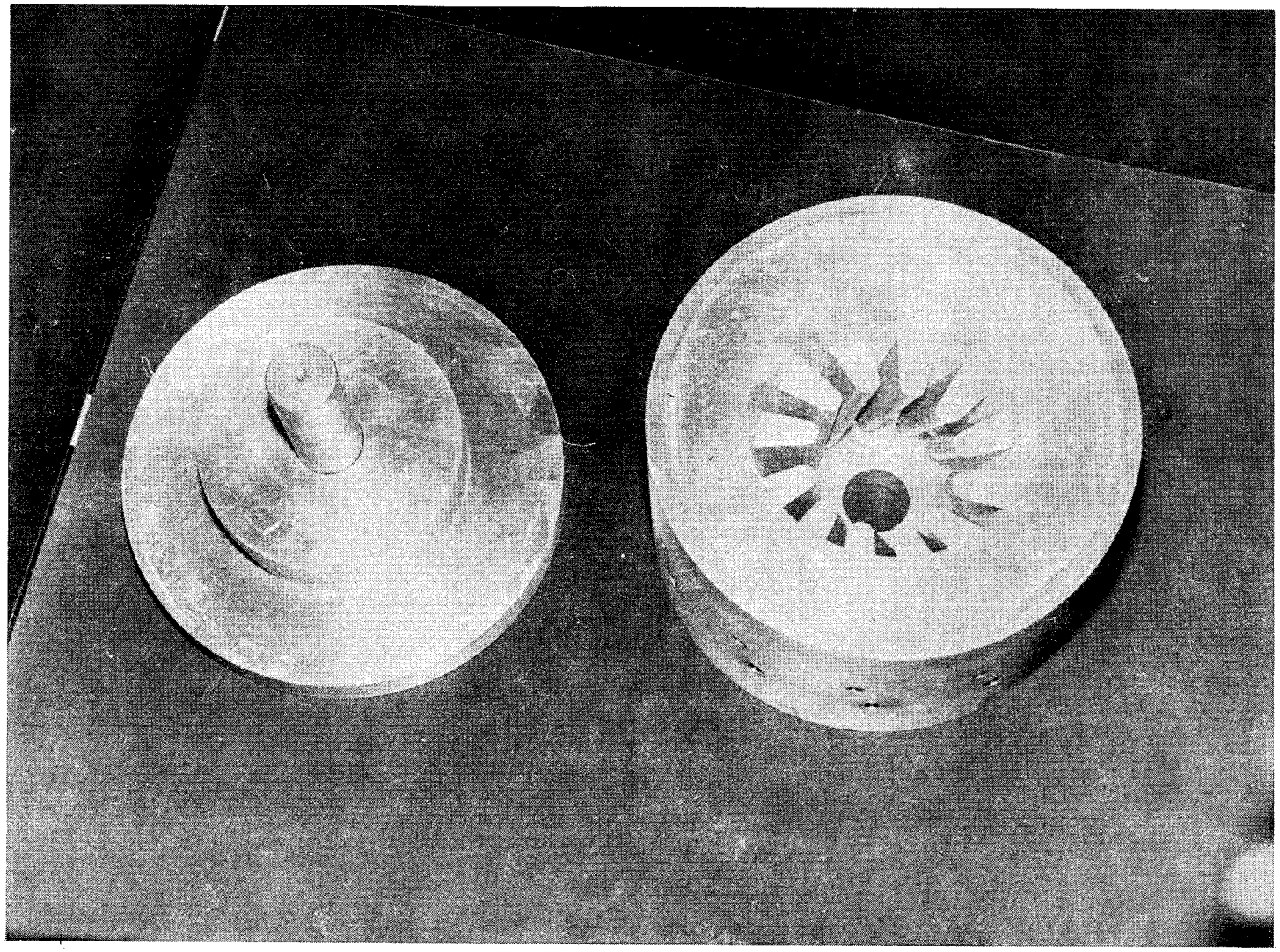

Figure 7. Mold-Fan Blade Hub

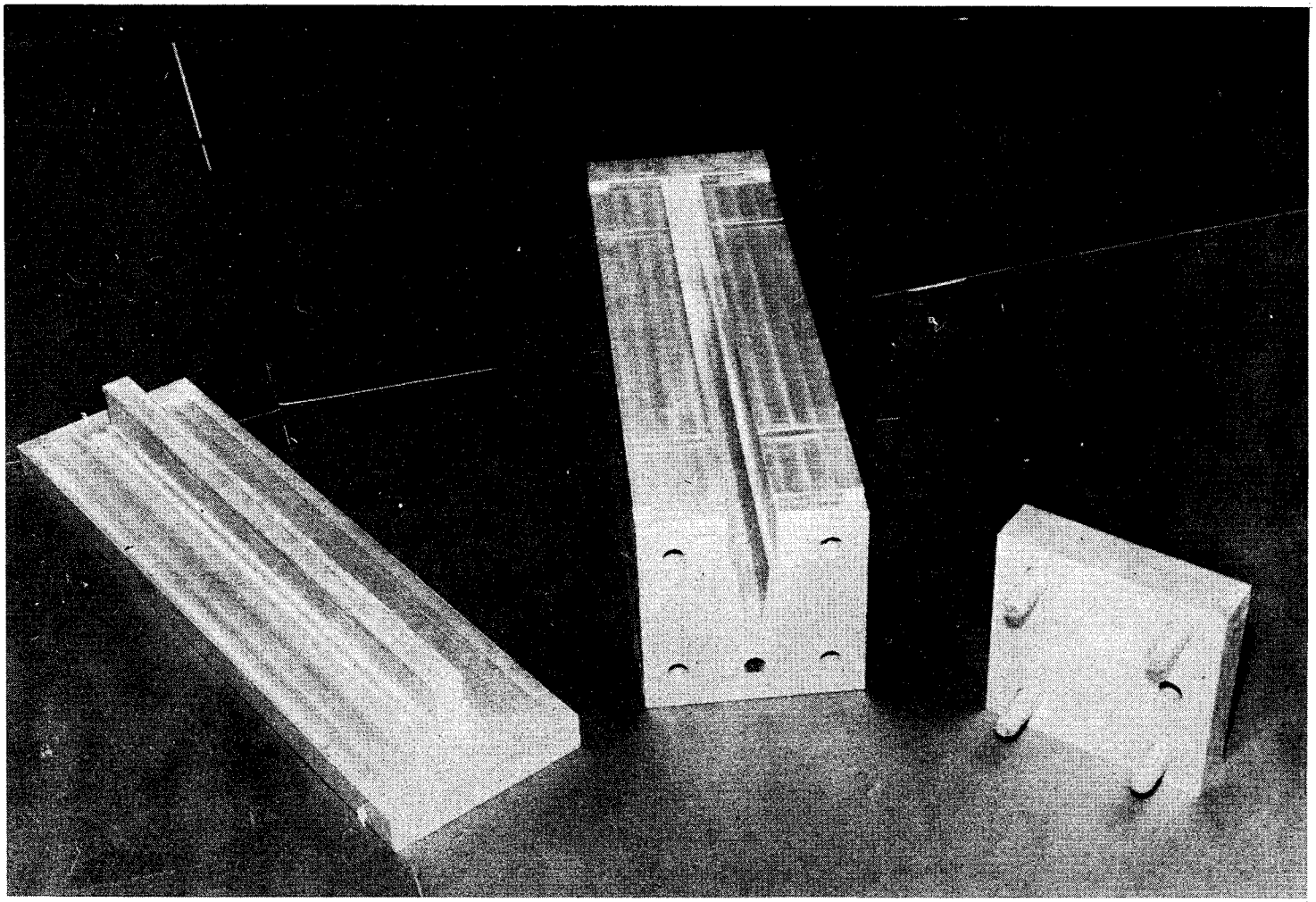

Figure 8. Mold Keeper

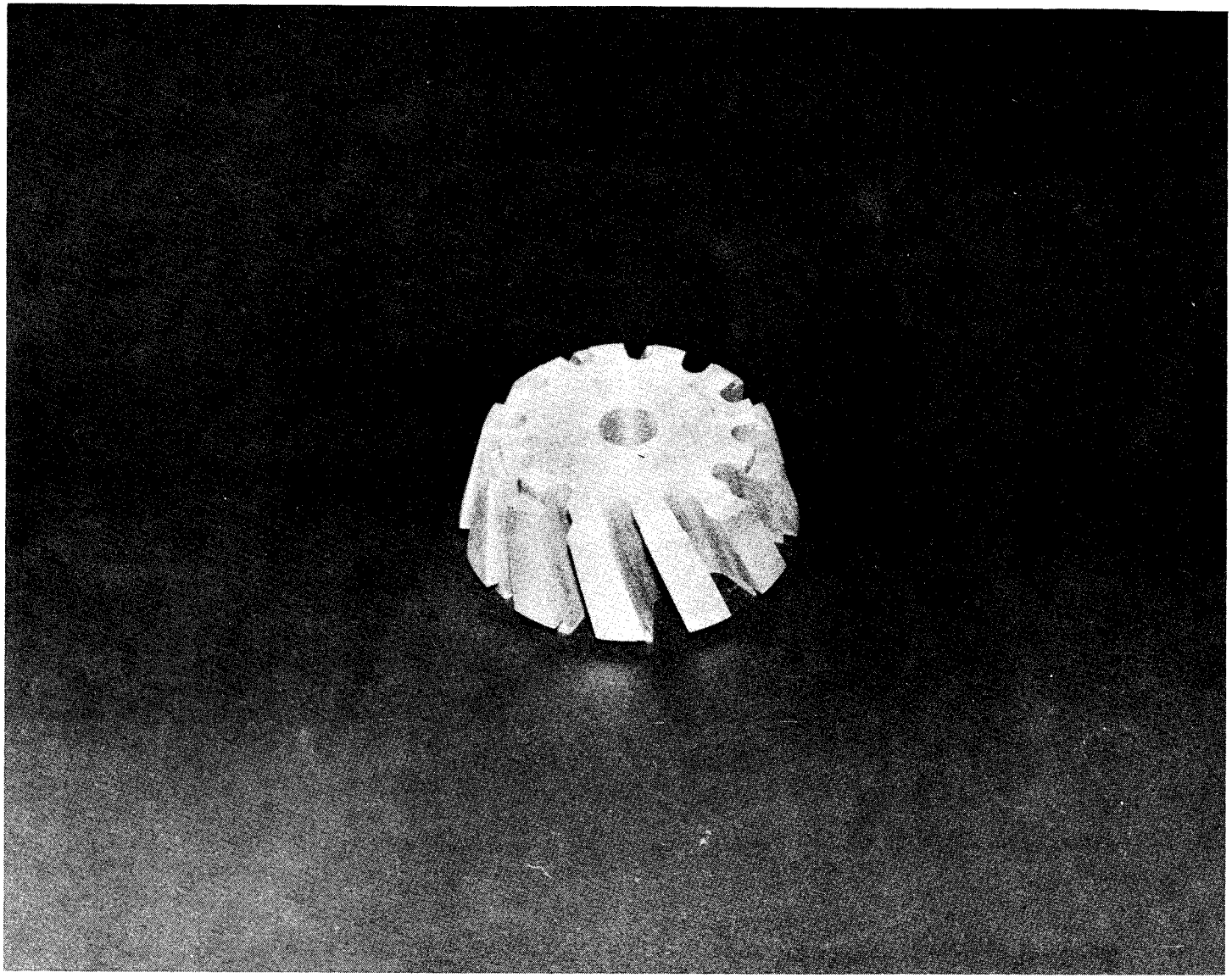

Figure 9. Keeper Fixture

## 5.0 FABRICATION

The hub and blade keepers were fabricated by compression molding as follows:

Hub

1. The hub mold (609-101) was coated with Ram 225 mold release (product of Ram Chemcial Company) and baked for 60 minutes at 200°F.

2. The keys were assembled (bolted) in place and the mold made ready for loading.

3. Chopped (.50 inch long) Thornel 300 graphite fibers and APCO 2447/APCO 2345 (7.5 PHR) resin were mixed in a 50% fiber volume ratio (39.31% resin by weight).

4. A portion of the graphite fiber/epoxy resin mixture was loaded into the mold using the loading tooling 609-104 to compact the mixture beneath and between the keys in the lower portion of the mold.

5. The remaining quantity of graphite/epoxy was loaded into the mold and the mold closed. Pressure was applied by a press to close the mold.

6. While under pressure the resin was cured four hours at 130°F plus two hours at 250°F.

7. The part was slowly cooled to room temperature and removed from the mold. Keys were unbolted from the mold and removed from the mold with the part. The keys were then removed individually from the molded hub.

Blade Keepers

1. The blade keeper mold 609-102 was coated with Ram 225 mold release and baked 60 minutes at 200°F.

2. Unidirectional Thornel 300 graphite impregnated with APCO 2447/APCO 2345 (7.5 PHR) 50% fiber volume were laid into the bottom of the mold and the remaining portion filled with the same material except the

2. (Continued)

fibers were chopped into a .50 inch long lengths.

3. The mold was closed and pressure applied by a press and cured four hours at 130°F plus two hours at 250°F.

4. The part was slowly cooled to room temperature and removed from the mold.

5. The part was cut into lengths approximately 1.8 inches long and 12 sections were secured with a banding clamp to the keeper fixture 609-103.

6. The keepers were machined on their outside surface while supported in the keeper fixture. The blades and blade keepers were coated in their attachment areas with resin (APCO 2347/APCO 2345) and assembled to the hub and secured by overwinding the keeper edges with Thornel 300 impregnated with APCO 2447/ APCO 2345 (7.5 PHR). Following winding the assembly was cured four hours at 130°F plus two hours at 250°F plus two hours at 400°F. The rotor assembly was slowly cooled to room temperature, cleaned up and shipped.

# 6.0 RESULTS

A total of two composite hub/metal blade compressor rotor assemblies were fabricated and shipped to NASA. The rotors demonstrated the feasibility of fabricating low cost rotors by this process. However, precise blade alignment was difficult to achieve with the tooling use.

# 7.0 CONCLUSIONS

It is concluded that composite hub/metal blade compressor rotor assemblies are practical to fabricate. The tooling used was adequate except the slots in the hub cannot be relied upon to give precise alignment of the metal blades. The alignment problem of the blades can be eliminated by changing the blade base configuration from a curve to a flat surface. This flat surface would provide positive alignment and eliminate the rotation problem of the blades during assembly.

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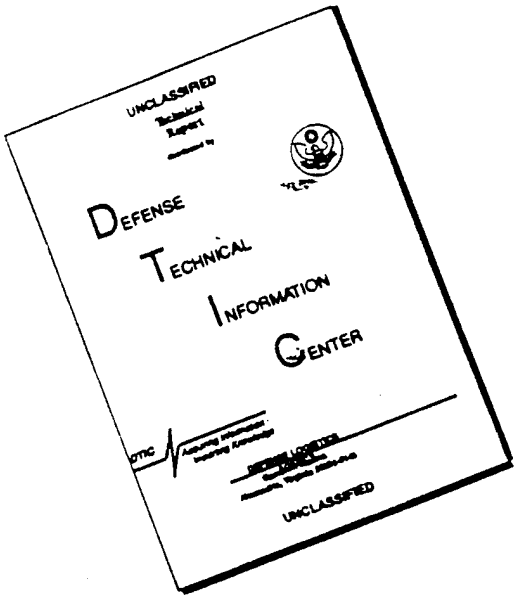


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